

Update on Tevatron Collider Run II

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HEPAP meeting

August 5, 2002

The Tevatron Collider Program



The Collider Run II is the most important activity at Fermilab.

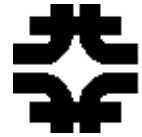
Physics of the Weak Energy Scale

- Precise t , W mass measurements
—
- Supersymmetry searches
- Search for new physics: hidden dimensions, strong dynamics, ...
- Low-mass Higgs search, in time

CP Violation and Quark Flavors



Run IIa Luminosity Goals

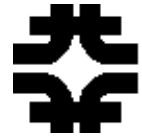


- **Run IIa** refers to operations supported by the collider configuration described in the Main Injector Project documents.
 - The official luminosity goal for Run IIa was defined in the data sheet for the Main Injector Project:

“The Tevatron proton-antiproton colliding beam luminosity will be increased to at least $5 \times 10^{31} \text{cm}^{-2} \text{sec}^{-1}$.”

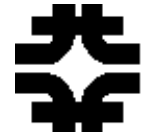
 - This would lead in a few years to an integrated luminosity $\sim 2 \text{ fb}^{-1}$.
 - In addition, we are doing everything feasible to exceed those goals with additional effort and the Recycler. We believe the limits are:
 - 8×10^{31} with the present configuration
 - 2×10^{32} with full benefit of the Recycler
 - These are our ambitious goals, pushing the accelerator complex an order of magnitude beyond previous performance

The year so far

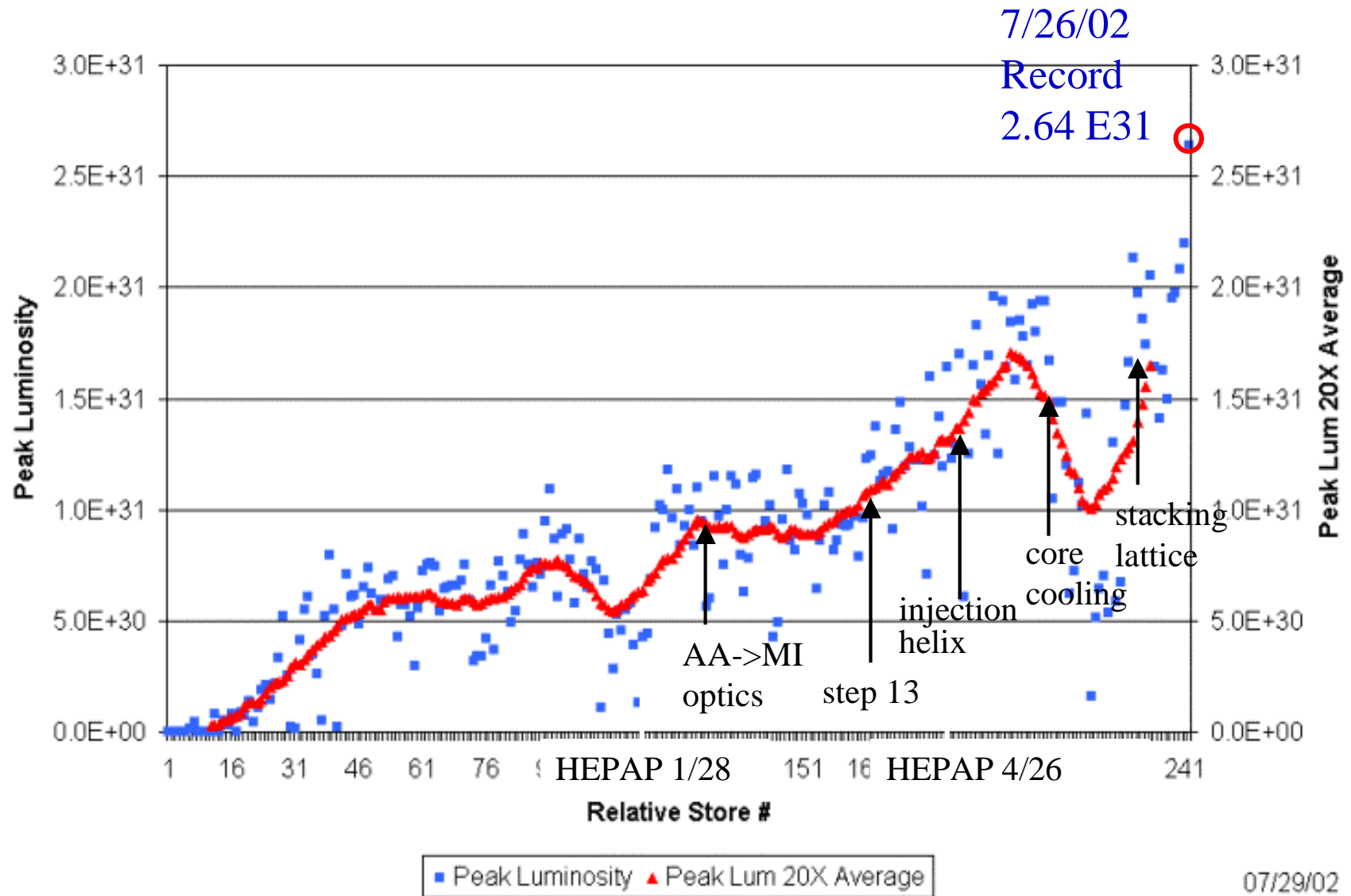


- 1/1 to 3/15
 - Typical $L \cong 1E31$ Weekly $\cong 1 \text{ pb}^{-1}$
 - Work on diagnostics, studying how to improve transfers and lifetimes
- 3/15 to 5/21
 - Typical $L \cong 1 \rightarrow 1.8E31$ Weekly $\cong 1 \rightarrow 3 \text{ pb}^{-1}$
 - Doubling of luminosity due to several 20% improvements.
- 5/21 to 7/1
 - Shutdown to install new stochastic cooling in antiproton accumulator
 - Development of new shot lattice to further improve pbar cooling
 - Some setbacks in luminosity and reliability
- 7/1 to 8/5
 - Restored reliable operations
 - Integrated new pbar lattice into operations
 - **Record luminosity $2.64E31$ 7/26/02**

Performance: Peak Luminosity



Collider Run IIA Peak Luminosity

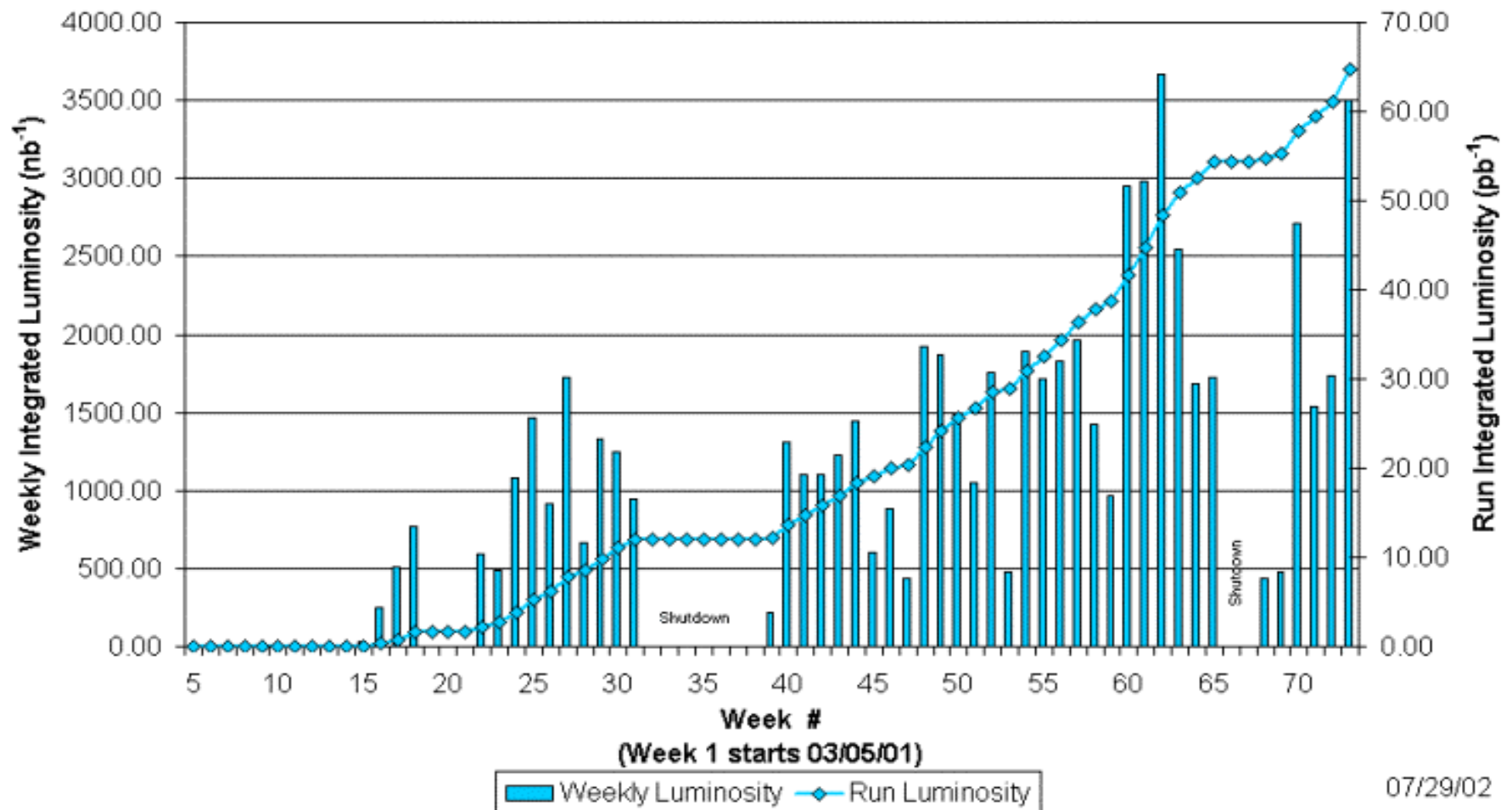


07/29/02

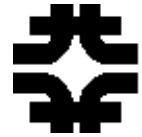
Weekly integrated luminosity



Collider Run IIA Integrated Luminosity

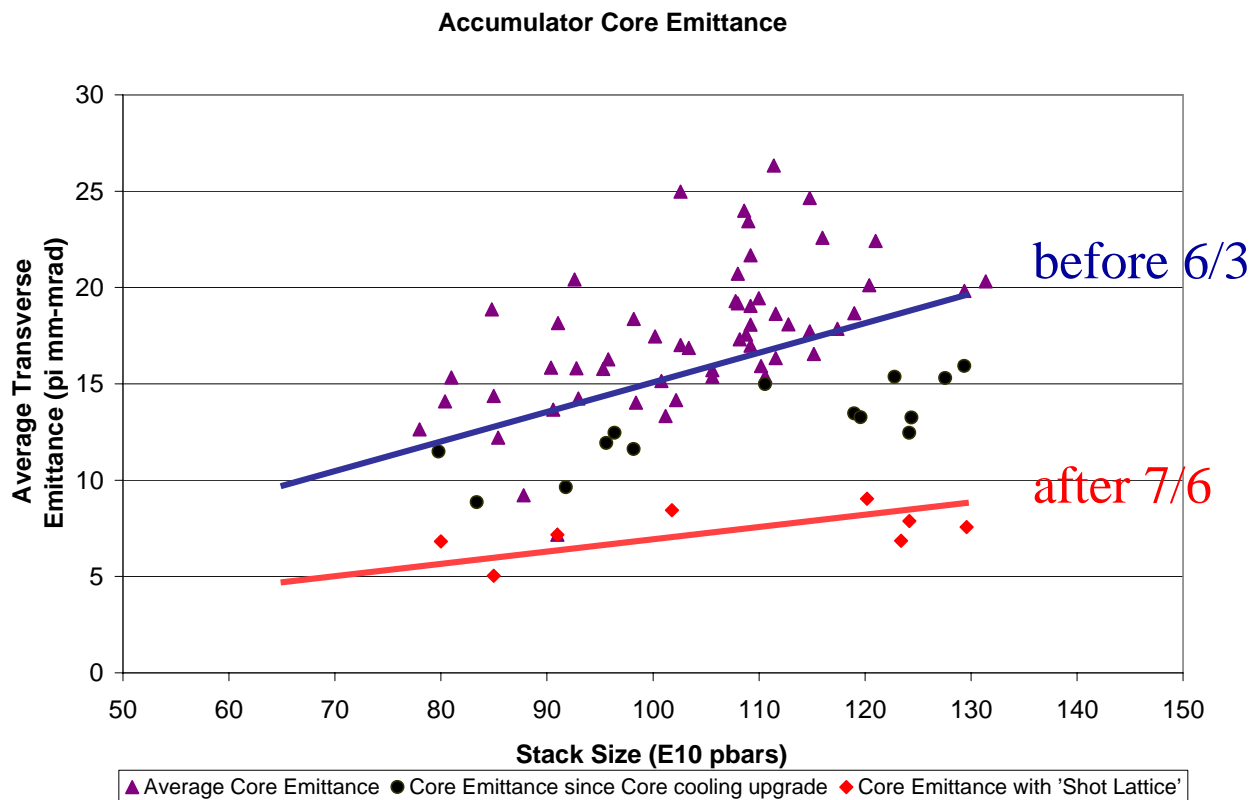


The Major Problems (as of 6/1/02)

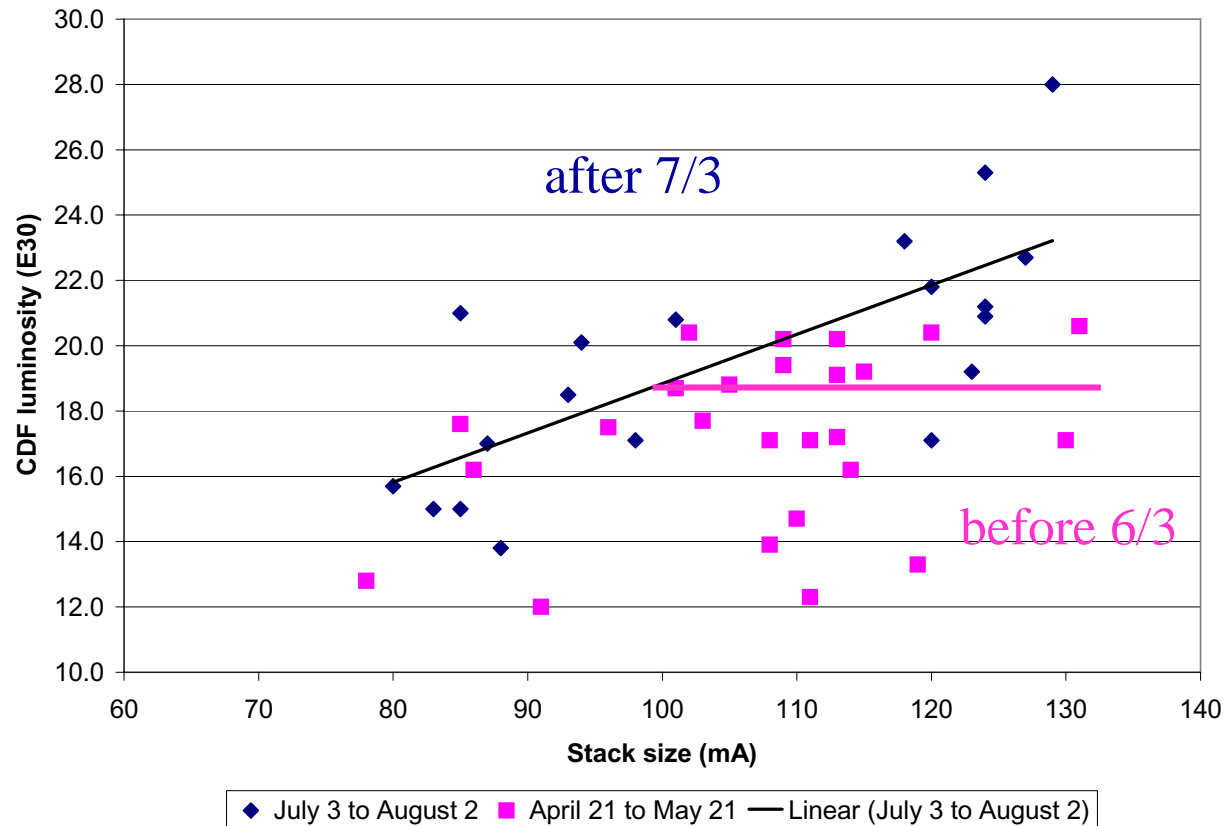


- **Transverse emittance of antiprotons**
 - lattice, cooling **successfully done; see plot*
 - preserving emittance from Accumulator to collisions
- **Long range beam-beam in the Tevatron**
 - helix
 - aperture
- **Backgrounds (esp. at CDF)**
 - vacuum
 - shielding
- **Other issues**
 - mismatch
 - coalescing
 - beam stability
 - lifetime at 150 GeV

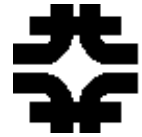
Accumulator core emittance vs pbar stack size



Luminosity vs pbar stack size

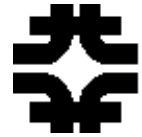


Additional effort on Run II



- We have reassigned people to Beams Division and reassigned Run II accelerator tasks to other divisions.
 - See next two pages for snapshot of growing list.
- As of July 15, Steve Holmes is Acting Beams Division Head. Although he retains his role as Associate Director for Accelerators, he is spending full time in the Beams Division.
 - The sign on his door: “If it is not about Run II, I don’t want to talk about it.”
- We are preparing for more:
 - Lists from Particle Physics and Computing Divisions accounting for full effort of all scientists with information about criticality to key projects
 - List from Technical Division of things they could take on
 - List from Beams Division of Run II tasks and personnel needs
 - All-hands memo to the laboratory on additional help for Run II
- We are also making good use of accelerator experts from SLAC, LBL, CERN, BNL, and more.

Added key effort on Run II from the Technical Division



- P. Limon Chair of the Run II Advisory Committee
 & the Recycler effort
- New engineer & tech faster magnet repair and specialty magnet
 construction
- 1 engineer & 1 tech construction of kicker magnets
- R. Stanek magnet spares and vulnerability study
 D. Harding
- Y. Pischalnikov phototubes used for flying wires instrumentation
- G. Romanov studying vibration in the Tevatron RF cavities
 T. Khabiboulline as a possible source of heating
- P. Schlabach magnetic field monitoring of beam line magnets
- 20 technicians tasks during the upcoming shutdown
- Programmers c, c++, and Java programming

This is a growing list and there will be more in the near future.

Added key effort on Run II from the Particle Physics and Computing Divisions



- S. Pordes overall responsibility for Instrumentation.
- J.Spalding Project Manager for the Run IIb accelerator project
- H. Jostlein vacuum for the Recycler
- M. Larwill loss monitor system for the Booster
- C. Drennan flying wire system for the antiproton source
- C. Rivetta beam loading compensation in the Main Injector
- W. Johnson installation of beamline instrumentation
- S. Morrison
- H. Cheung Synchlight monitors
- A. Hahn
- P. Lebrun Shot Data Analysis (SDA)
- S. Panacek
- P. Spentzouris simulations of space charge effects in the Booster
- J. Amundson
- D.Slimmer labview software for the pbar flying wires system
- many technicians tasks during the upcoming shutdown

This does not include less formal study groups on, for example losses.

This is a growing list and there will be more in the near future.

Collider summary



- Luminosity improvements
 - The record luminosity is $2.64E31$.
 - We are pushing immediately toward $4E31$ and putting more emphasis on integrating luminosity.
 - We have increased *typical* initial luminosity from $\sim 0.8E31$ on 3/15 to $\sim 2.2E31$ on 7/31.
- Additional effort for Run II.
 - We already had increased funding for Run II out of rest of laboratory.
 - We have brought in substantial effort from other Divisions.
 - We have coupled help from other laboratories into the effort.
- We will have a new 12-month plan later in August that is grounded in what we now know.

Physics prospects in Run II

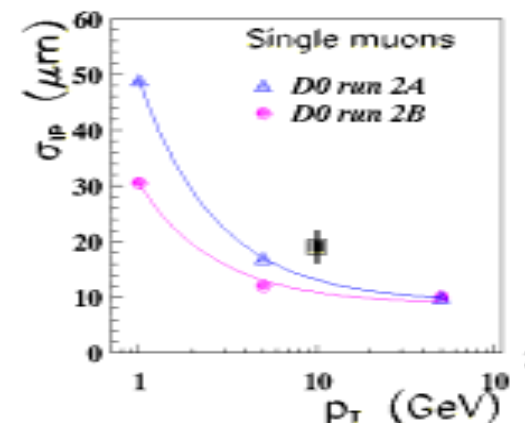


- Precise measurements, looking for cracks in the Standard Model:
 - top quark and W boson properties
 - measurements of B mixing and CP parameters
- Possible discoveries
 - Higgs boson
 - Supersymmetry
 - Extra dimensions
 - New dynamics (technicolor, new gauge bosons)
 - Quark or lepton compositeness
- The detectors are much improved over Run I, so each pb^{-1} is worth more.
- Every factor-of-2 increase in the integrated luminosity makes possible a new round of important physics results.
- First results were presented at ICHEP 2002 in Amsterdam...

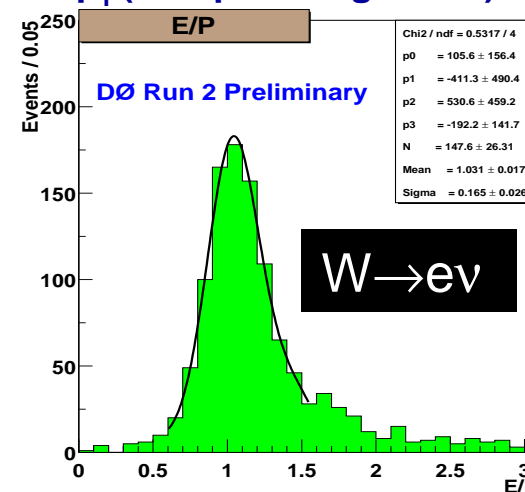
DØ status



- The detector is working and recording physics data
 - Both silicon and fiber tracker have hit efficiencies $> 98\%$
- Data are being reconstructed and analyzed with a latency of ~ 1 week
- First physics measurements presented at ICHEP
 - based on $5\text{-}10 \text{ pb}^{-1}$ of data
- Improvements still in store:
 - Trigger and DAQ system
 - Offline reconstruction (alignment, efficiencies)
- By next summer, physics results with a few hundred pb^{-1} :
 - Top quark
 - Jet cross section
 - Searches for physics beyond the SM
 - ...



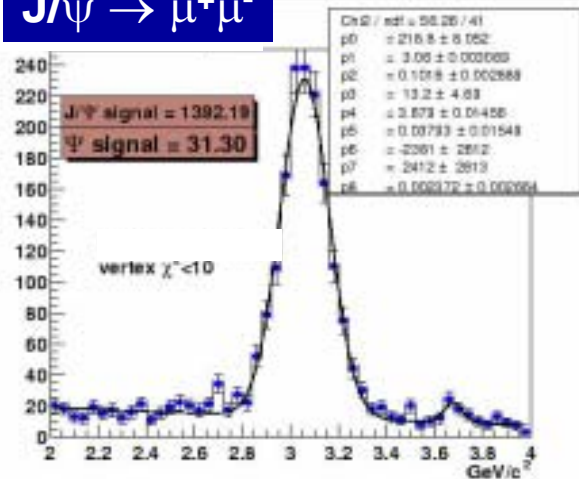
Impact Parameter Resolution vs p_T (first pass alignment)



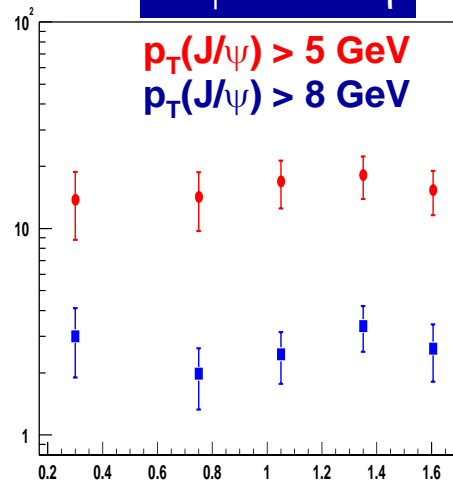
DØ detector performance



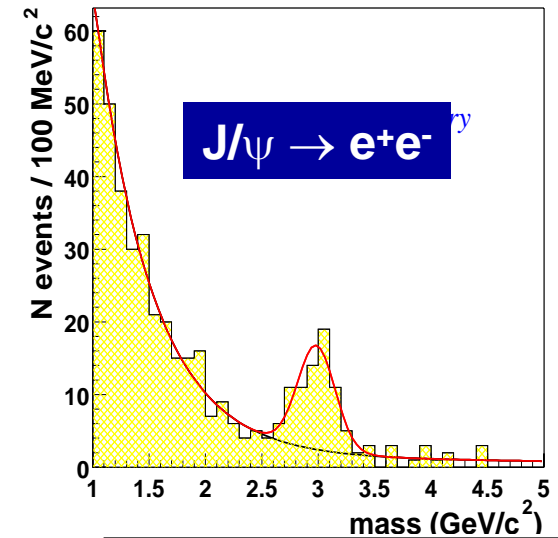
$J/\psi \rightarrow \mu^+\mu^-$



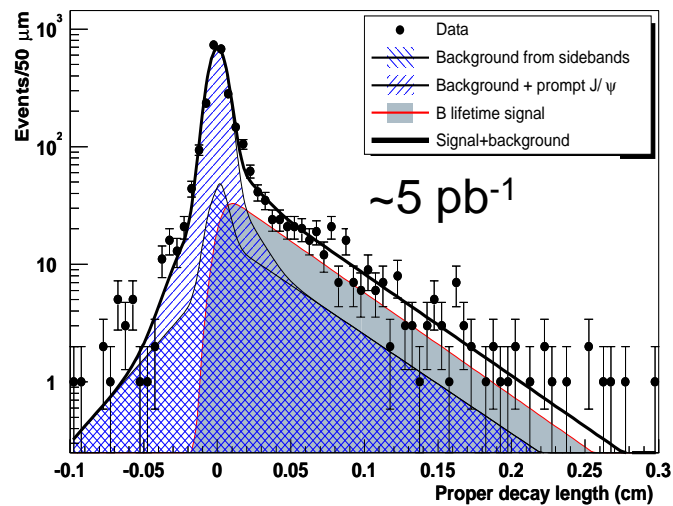
J/ψ σ vs. η



$J/\psi \rightarrow e^+e^- \gamma$

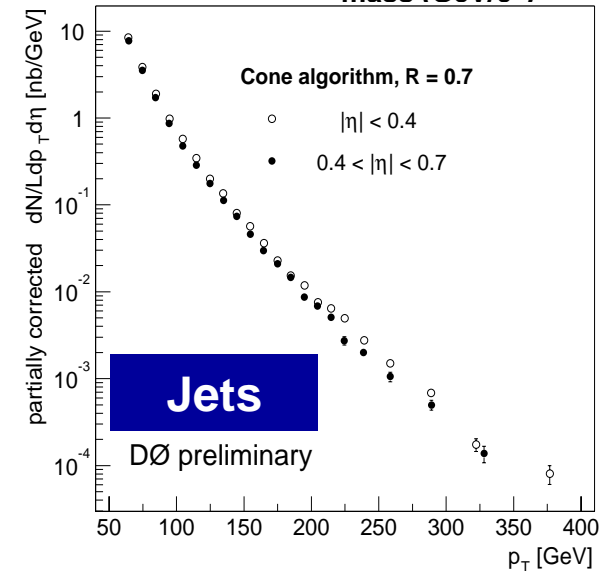
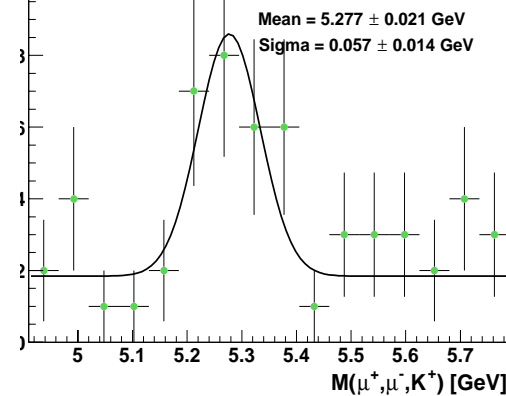


B decay length ($B \rightarrow J/\psi + X$)



$B^+ \rightarrow J/\psi K^+$

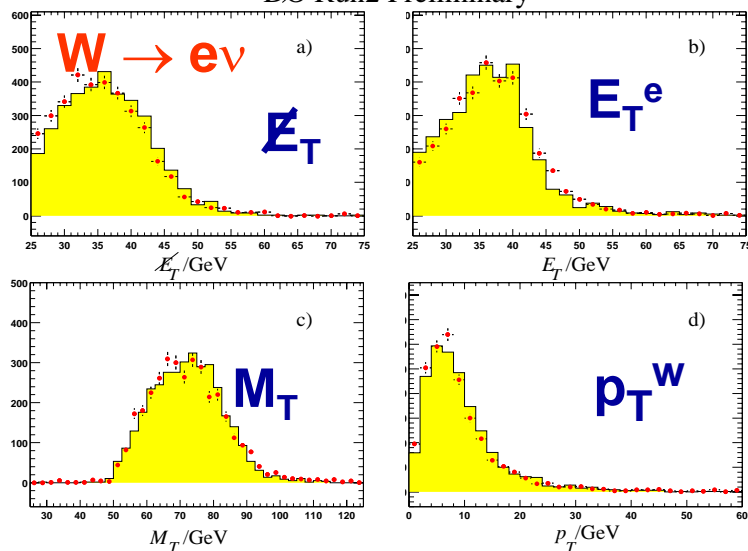
DØ Run 2 Preliminary



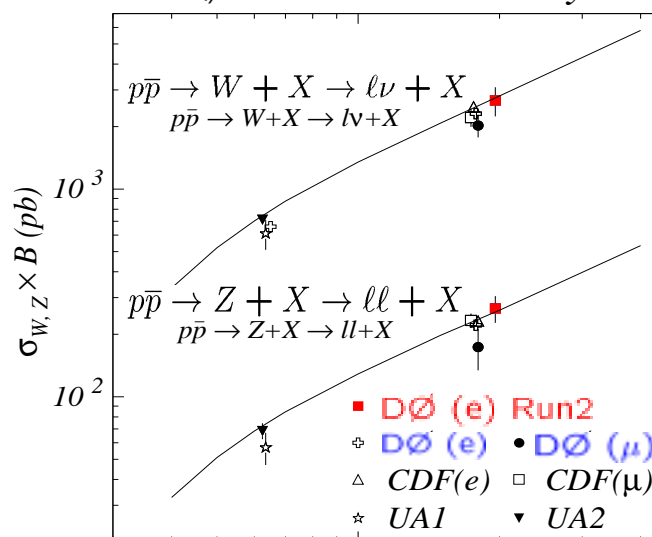
DØ W and Z measurements



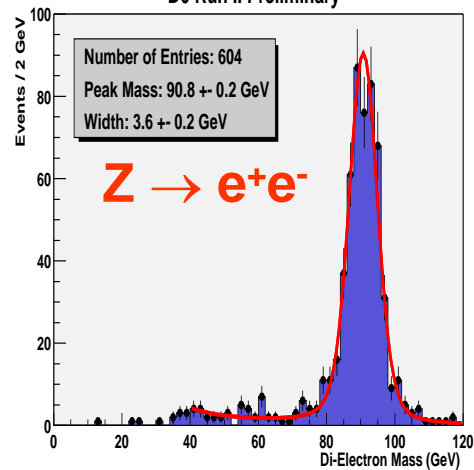
DØ Run2 Preliminary



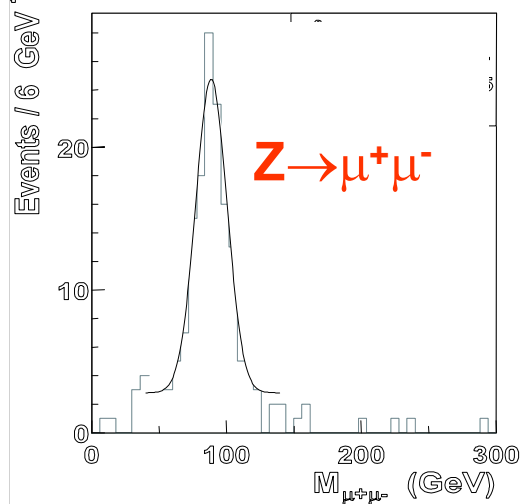
DØ Run2 Preliminary



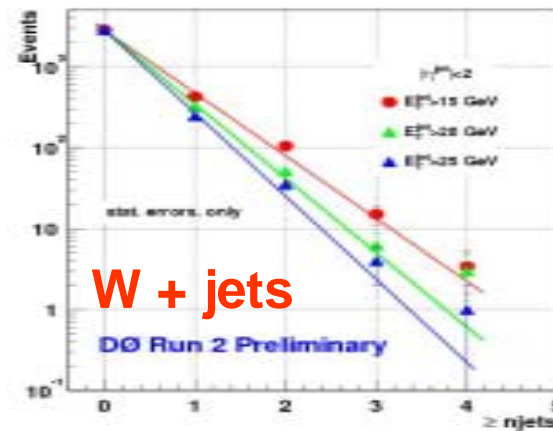
DØ Run II Preliminary



$\sqrt{s} \geq 15$ GeV



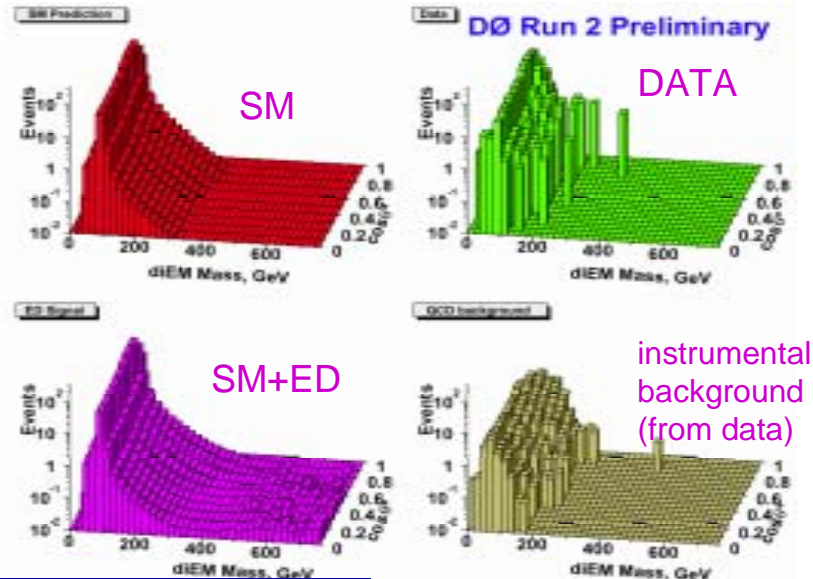
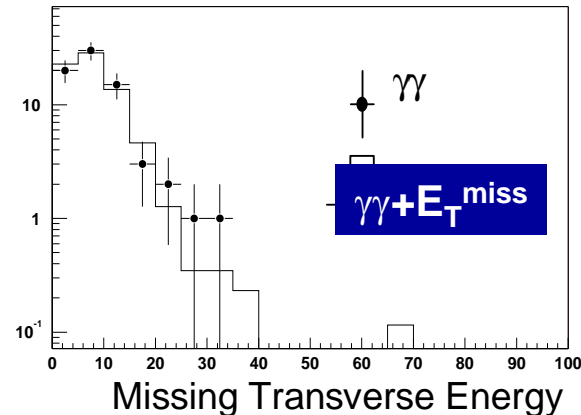
Center of Mass Energy (TeV)



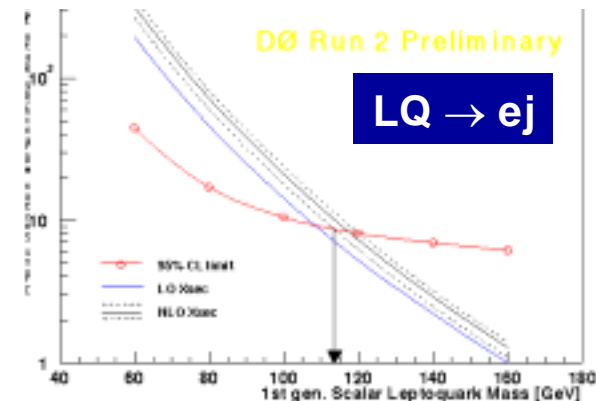
DØ searches for new phenomena



- Gauge mediated SUSY
 - Cross section for $\gamma\gamma + E_T^{\text{miss}} < 0.9\text{pb}$
- First generation leptoquark
 - $M_{\text{LQ}} > 113\text{ GeV}$ for $B(\text{LQ} \rightarrow ej) = 1$
- Extra dimensions
 - Limits from $ee, \gamma\gamma$ final state
 - $M_S(\text{GRW}) > 0.92\text{ TeV}$

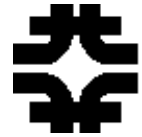


Extra Dimensions

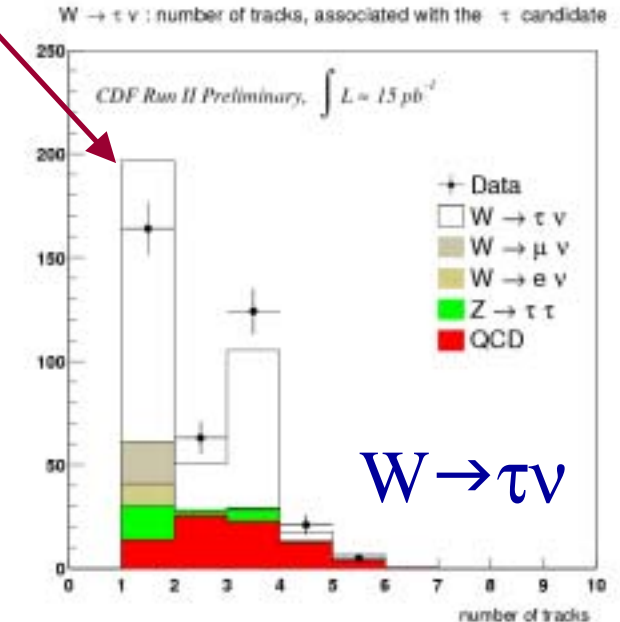


Run II limits are not yet competitive, but show that **DØ** is ready for physics

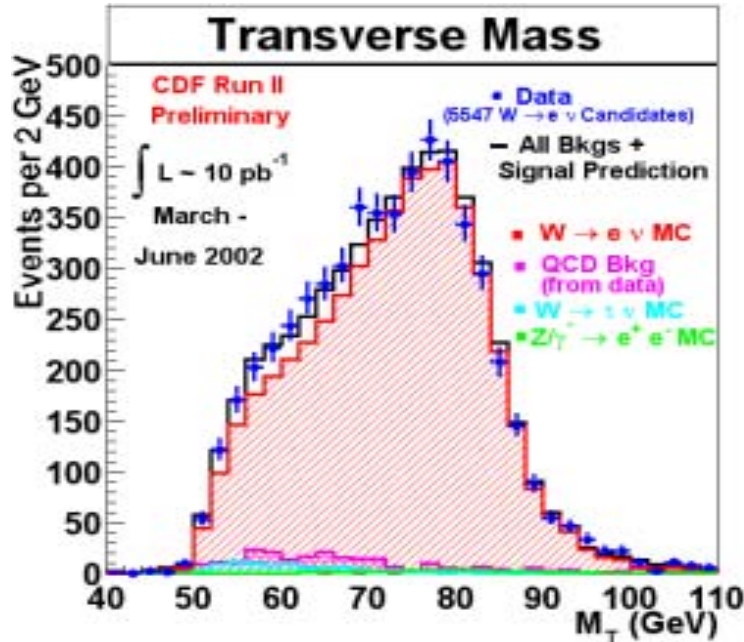
CDF-II Status



- Stable physics running established in early 2002
 - Complete Physics Trigger Table
 - ~140 triggers (e, μ , τ , ν , γ , jet, displaced track, b jet, ...)
- 23.5/pb recorded January-June 2002
- COT tracking performance excellent
 - $\epsilon = 99 \pm 1\%$ (L3/offline reconstruction)
- High Trigger efficiency
 - $\epsilon \sim 100\%$ (L1 calorimeter trigger)
 - $\epsilon = 96.1 \pm 0.1\%$ (L1 track trigger)
- Efficient Shift Operation – July record 98.6%
- Offline Farms keep up with data processing.



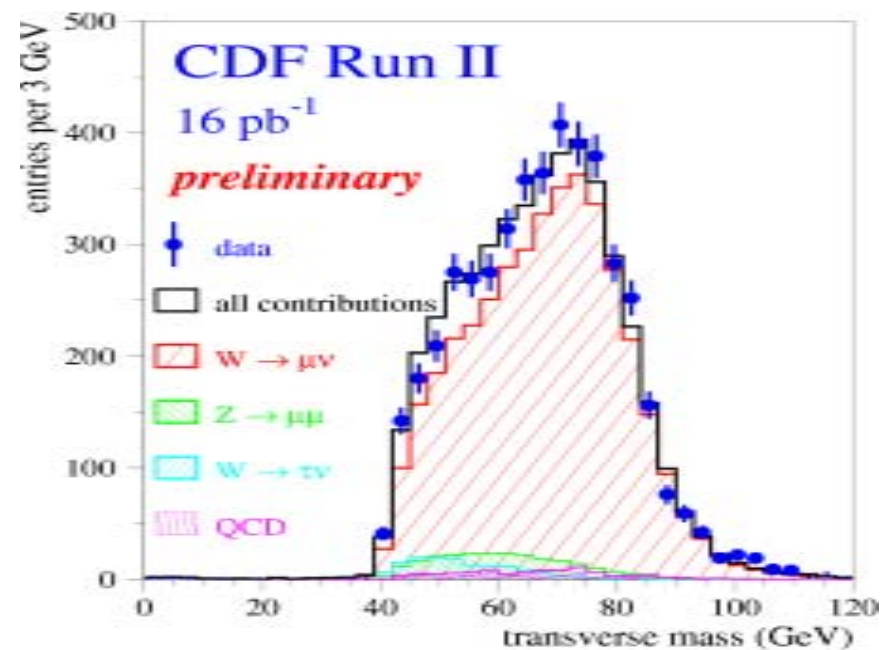
CDF Measurements of $\sigma B(W \rightarrow e\nu, \mu\nu)$



5547 candidates in 10 pb^{-1}

$$\sigma_W \cdot \text{BR}(W \rightarrow e\nu) \text{ (nb)} =$$

$$2.60 \pm 0.07_{\text{stat}} \pm 0.11_{\text{syst}} \pm 0.26_{\text{lum}}$$



4561 candidates in 16 pb^{-1}

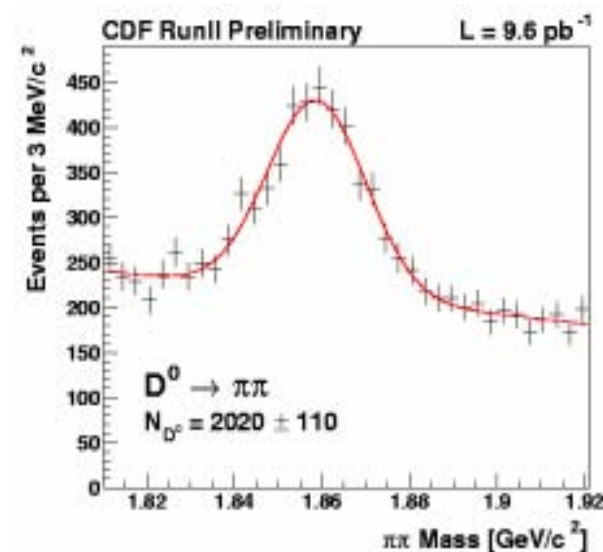
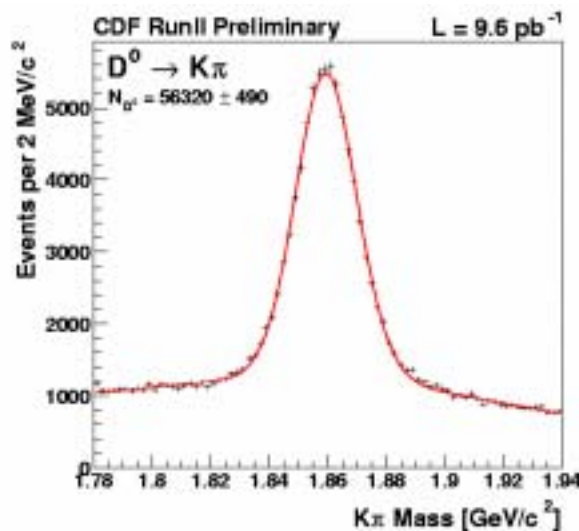
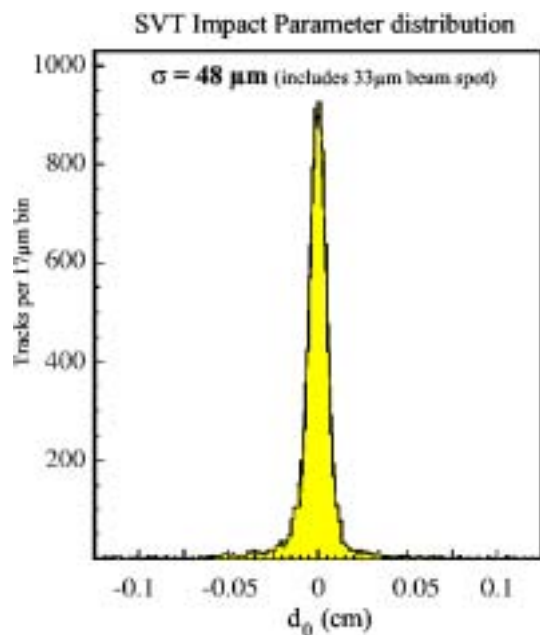
$$\sigma \cdot B(W \rightarrow \mu\nu) =$$

$$2.70 \pm 0.04_{\text{stat}} \pm 0.19_{\text{syst}} \pm 0.27_{\text{lum}}$$

Run 1 scaled to 1.96 TeV: $2.72 \pm 0.02_{\text{stat}} \pm 0.09_{\text{syst}} \pm 0.10_{\text{lum}}$

Toward M_W and M_{top} for M_{Higgs} constraints

CDF: SVT selects huge charm signals



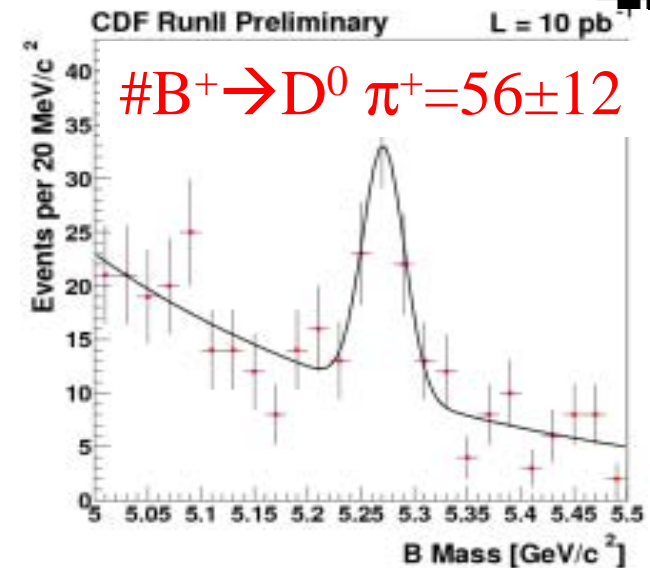
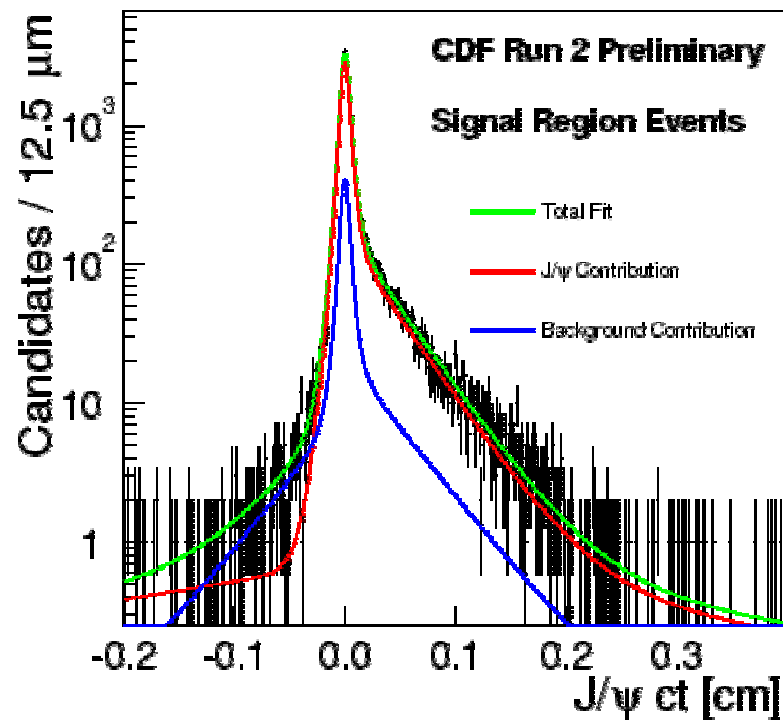
Si in $20 \mu\text{s}$ with offline accuracy

Millions of reconstructed charm in Run IIa

- $\Gamma(D \rightarrow KK)/\Gamma(D \rightarrow K\pi) = (11.17 \pm 0.48 \pm 0.98)\%$ (PDG: 10.83 ± 0.27)
- $\Gamma(D \rightarrow \pi\pi)/\Gamma(D \rightarrow K\pi) = (3.37 \pm 0.20 \pm 0.16)\%$ (PDG: 3.76 ± 0.17)

Already comparable!

CDF: B signals including hadronic triggers

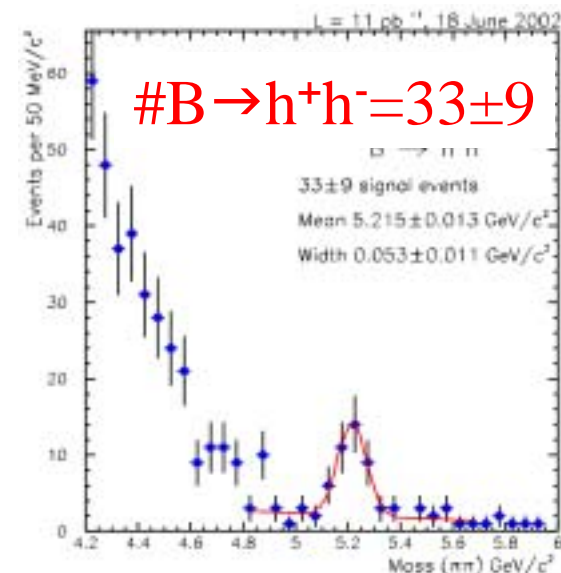


- Inclusive B lifetime with J/ψ 's

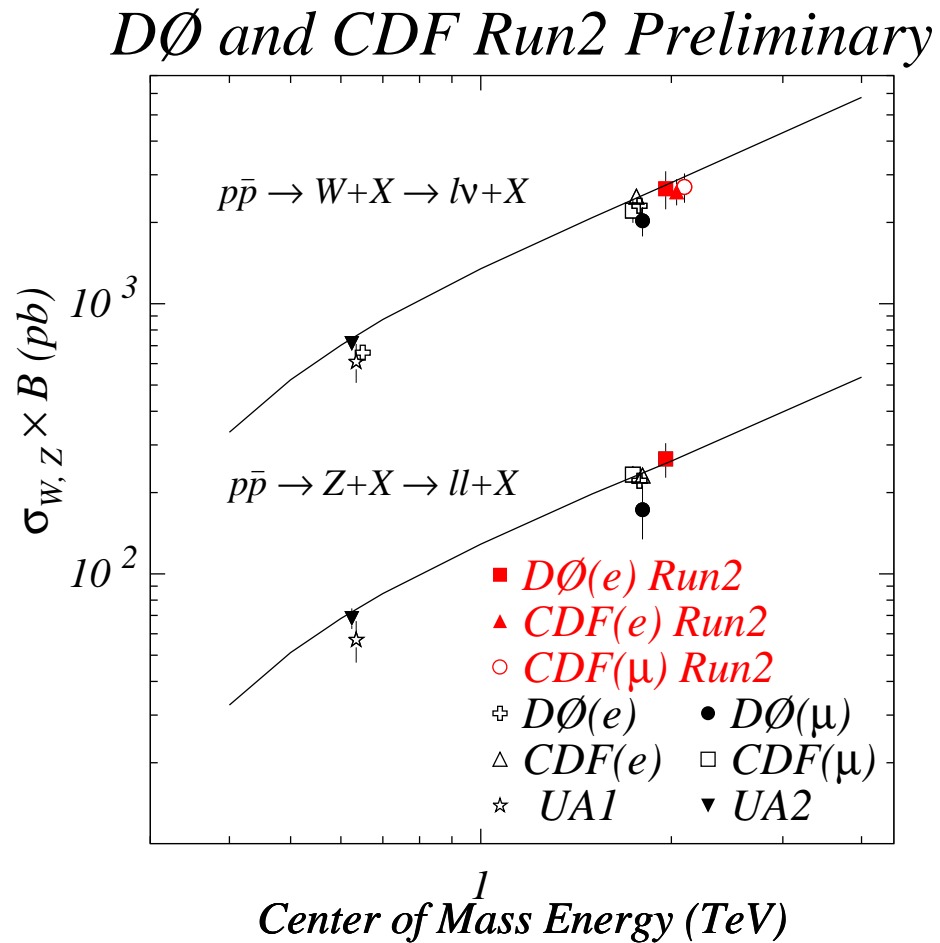
$$c\tau = 458 \pm 10_{\text{stat.}} \pm 11_{\text{syst.}} \mu\text{m} \quad (\text{PDG: } 469 \pm 4 \mu\text{m})$$

- Exclusive $B^+ \rightarrow J/\psi K^+$ lifetime

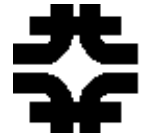
$$c\tau = 446 \pm 43_{\text{stat.}} \pm 13_{\text{syst.}} \mu\text{m} \quad (\text{PDG: } 502 \pm 5 \mu\text{m})$$



D0 and CDF W cross sections

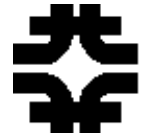


Run IIb



- Additional luminosity provides greater precision for electroweak measurements, greater reach for exotic searches, plus the opportunity to observe a low-mass Higgs boson.
- **Accelerator**
 - Improve luminosity by factor of 2-3 with a number of modest upgrades.
 - Accelerator advisory committee reviewing progress.
 - Right now, the attention must be concentrated on run IIa.
- **Detectors**
 - Two upgrade projects:
 - Replace partly rad-damaged silicon detectors with new detectors of simpler design with more rad-hard technology.
 - Upgrade data acquisition and triggers to deal with higher luminosity.

PAC at June meeting



- Physics is compelling.
 - “Even non-observation of the Higgs in Run IIb would be a result of extreme importance. If the Higgs is not observed, 95% CL exclusion over the mass range required by the electroweak precision data would put the Standard Model in crisis.”
- Upgrades are needed.
 - “Maintaining the capabilities of the CDF and D0 detectors throughout the run is ... essential for the success of Run II.”
- “The Committee recommends Stage I approval for the CDF and D0 Run IIb upgrade projects.”
 - Silicon detector upgrades are well-specified and need to start construction right away.
 - Non-silicon upgrades are needed.
 - Some of the detailed design needs more results from data.
 - Construction of individual components will start as needed.

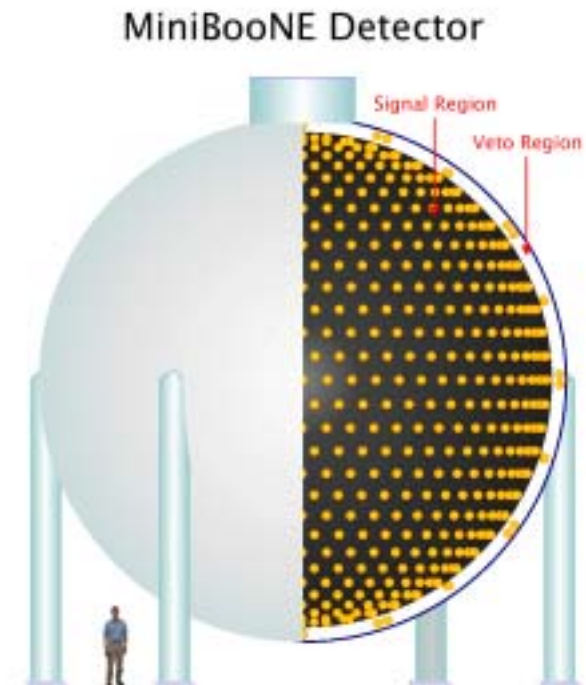
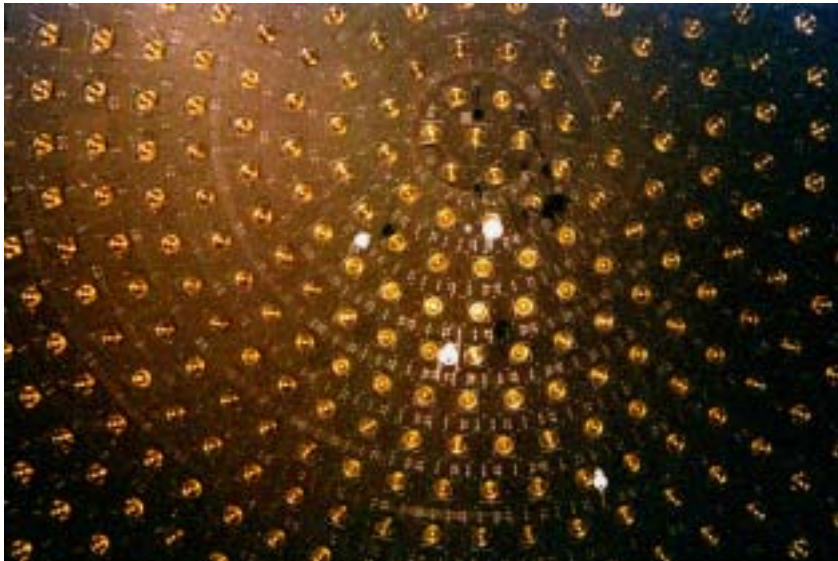
MiniBooNE is about to start.

- First neutrinos in a few days!

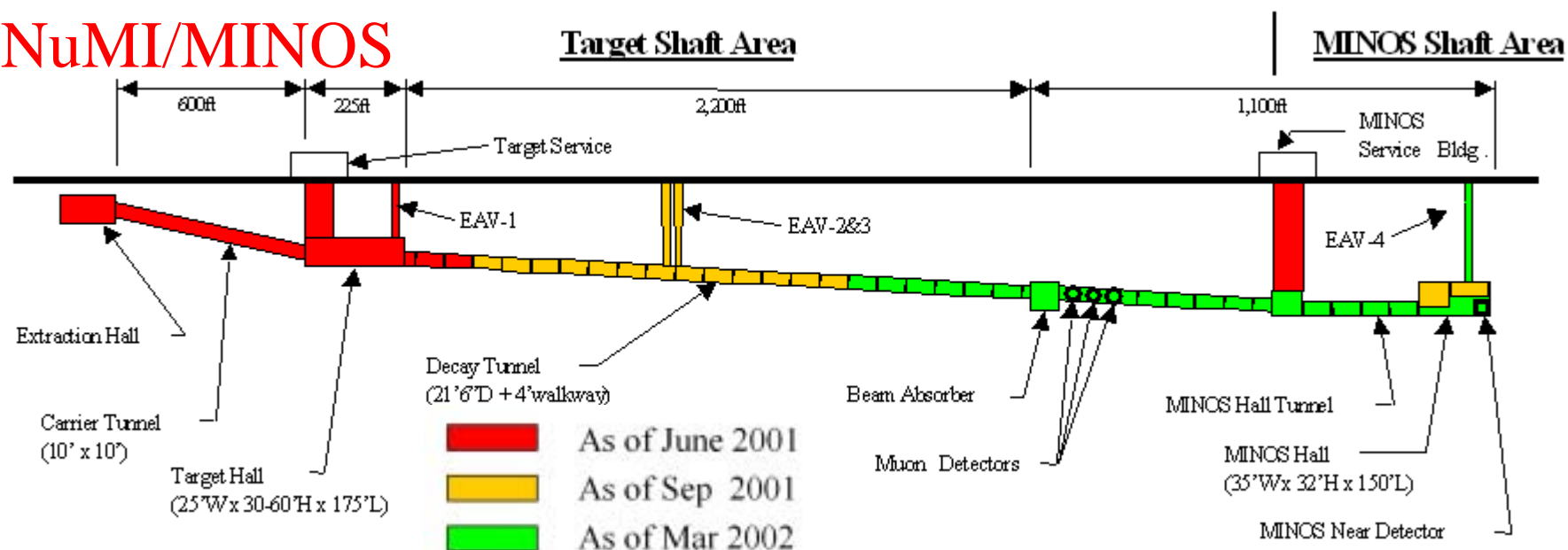
- Detector is being tested with cosmic muons.

- Proton beam has been commissioned.

- Ready to go.**



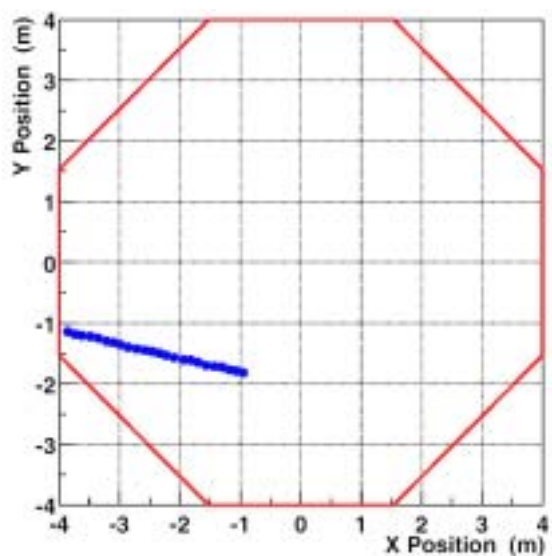
NuMI/MINOS



Decay pipe now complete



First neutrino event



First supermodule complete



Summary



- The luminosity has improved by $\sim 2.5\times$ since 3/15.
- We have added more effort to Run II.
- We will have a new 12-month plan later in August.
- The detectors are operating and recording high-quality physics data.
- The detector performance is as expected.
- The offline reconstruction is keeping up and the results look good.

Tevatron Physics is back.

- We are pushing even harder for additional increases in the Tevatron luminosity.